Triadimefon Controls Fusiform Rust in Young Slash Pine Outplantings

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ABSTRACT

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Triadimefon, sprayed on slash pine (*Pinus elliottii* var. *elliottii*) seedlings immediately before outplanting and at 2-wk intervals from April through June, reduced incidence of stem and branch fusiform rust infections caused by *Cronartium quercuum* f. sp. *fusiforme*. After 2 yr, 28% of the unprotected and 2% of the protected trees had stem galls; differences associated with weeding, bedding, and fertilizer were not significant. In cultivated plots, 39% of the unprotected and 1% of the protected trees had galls in branch tissue formed during the second year, with no differences attributed to bedding or fertilizer. Further study is needed before general use of triadimefon in industrial and public reforestation can be recommended, but its usefulness in protecting research or other high-value pine plantings is indicated.

Fusiform rust, caused by *Cronartium quercuum* (Berk.) Miyabe ex Shirai f. sp. *fusiforme*, rare in the early 1900s, is now the most serious pest of the southern pines. Its dramatic increase in distribution and impact has coincided with the increase in timber management intensity (1). Site preparation, repeated cultivation, applied fertilizer, and other cultural practices usually are followed by heightened levels of rust infection (4,5). Slash and loblolly pines (*Pinus elliottii* Engelm. var. *elliottii* and *P. taeda* L.), the most widely planted southern pines and the most susceptible to fusiform rust, are most readily infected during their first 10 yr (2). A systemic fungicide capable of controlling rust during the first few years of the life of a pine plantation would be highly desirable. Contact fungicides require respraying following every rain, and application costs would be uneconomic. Triadimefon is a systemic fungicide whose effectiveness in preventing fusiform rust has been demonstrated in pine tree nurseries (6). The purpose of the experiment reported here was to evaluate it for control of fusiform rust in young slash pine plantings, using four levels of culture.

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MATERIALS AND METHODS

Levels of culture were check (C), weeding (W), weeding plus bedding (WB), and weeding plus bedding plus fertilizer (WBF). Two levels of fungicide, one of which was zero, were tested in all eight combinations in randomized complete blocks replicated three times.

Seeds from a bulk lot labeled South Mississippi Slash Pine 1973 were sown in styrofoam containers. Seedlings were grown for 14 wk in a greenhouse and outplanted in April 1979.

The study area was prepared by clearing the understocked oak-pine forest the summer before planting. Trees were felled and skidded. The C plots received no further treatment except planting. Six months before planting, the W plots were flat-disked, the WBF plots were fertilized, and the WB and WBF plots were bedded. Triple superphosphate was broadcast at 246.6 kg of P_2O_5/ha to WBF plots. Bed formation mixed the 0-46-0 fertilizer with the soil. Beds were about 25 cm high when formed, oriented due east-west, and 2.44 m apart between centerlines. Ammonium nitrate at 224.2 kg of N/ha was applied in a circle, 30 cm in radius, around each tree in July after planting. Weeding was accomplished by yearly sprayings of simazine (1.4 kg a.i./ha) and dalapon (2.7 kg a.i./ha) in April, followed by glyphosate (2.5 kg a.i./ha) in July accompanied by sufficient manual hoeing to maintain an essentially weedfree condition.

Competing vegetation in C plots, in order of importance, consisted of *Andropogon* grasses, blackberry (*Rubus* spp.), southern bayberry (*Myrica cerifera* L.), and greenbrier (*Smilax* spp.). The competition overtopped the planted pines in the C plots during the first 2 yr.

The silt loam soils in the study area were very strongly acid (mean pH = 4.8), low in plant nutrients, droughty in summer, intermittently waterlogged in winter, and nearly level. Each plot measured 29.3 × 25.6 m and contained 168 trees in 12 rows of 14 trees. Spacing was 1.83 × 2.44 m. Data were collected from the six rows of eight trees at the center of each plot.

The fungicide spray mixture was 1.585 g of triadimefon (Bayleton 50 WP) and 1.649 ml of Agri-Dex surfactant per 1 L of water. Hand-pumped backpack sprayers were used to spray each seedling until the entire shoot was thoroughly wetted. Fungicide was first applied 1 day before planting, on 24 April; subsequent sprayings were done on 8 and 22 May and on 5 June. In the second year, triadimefon was sprayed on 1, 13, and 29 April and on 12 and 22 May. These dates spanned the period when basidiospore dissemination usually occurred.

Tree survival and height were observed at the end of the first and second growing seasons. A preliminary appraisal of fusiform rust incidence was made in November the first year, and infection data for statistical analysis were collected in early March following the second growing season. Symptoms of disease were stem galls originating in stem tissue that formed in the first year; galls that originated in branches and expanded into stem tissue that formed in the first year; stem galls originating in stem tissue that formed in the second year (ie, acropetal to the first-year resting bud scar); galls in branches that formed in the first year; and galls in branches that formed in the second year.

Analysis of variance employed a factorial model. When the fungicide × culture interaction was significant at the 0.05 level, differences between culture means within fungicide level were tested by Duncan's new multiple range test. When the interaction was not significant, the main effect of culture (3 d.f.) was tested by Duncan's test, and the main effect of fungicide (1 d.f.) was tested by the error mean square (14 d.f.).

RESULTS

In both the first and second years, the percentage of trees with stem galls of stem origin was significantly reduced by the fungicide; the effects of culture and the fungicide × culture interaction were not significant (Table 1). Most of the stem galls originated in the stem, and most of them appeared in the first year. Branch

Table 1. Incidence of fusiform rust in 2- and 1-yr-old stem and branch tissue of slash pine 2 yr after outplanting when protected and unprotected by the systemic fungicide triadimefon

Infection and date of origin	Fungicide[w]	Incidence (%) in trees having culture[x,y]				
		C	W	WB	WBF	Mean
Stem galls	No	22.2	22.2	29.9	16.7	22.7 b[z]
in stem tissue, 1979	Yes	0.7	1.4	1.4	2.8	1.6 a
	Mean	11.4 ab	11.8 ab	15.6 b	9.7 a	
Stem galls	No	23.6	26.4	34.7	23.6	27.1 b
in stem or branches, 1979	Yes	0.7	1.4	1.4	2.8	1.6 a
	Mean	12.2 a	13.9 a	18.1 a	13.2 a	
Stem galls, 1980	No	3.5	2.1	2.8	0.7	2.3 b
	Yes	0	0	0	0.7	0.2 a
	Mean	1.7 a	1.0	1.4 a	0.7 a	
Branch galls, 1979	No	0.7	5.6	3.5	5.6	3.8 b
	Yes	0	0	0	0	0 a
	Mean	0.3 a	2.8 a	1.7 a	2.8 a	
Branch galls, 1980	No	0 a	37.5 b	38.9 b	41.7 b	...
	Yes	0 a	0.7 a	2.1 a	1.4 a	...
	Mean	...	...	...	...	

[w] Protected seedlings were sprayed to wetting with 1.585 g of triadimefon per liter of water at 2-wk intervals four times in the first year, beginning 24 April, and five times the second year, beginning 1 April.

[x] Each value is the mean of three observations; each observation plot contained 48 trees.

[y] C = check; W = weeded; WB = weeded, bedded; WBF = weeded, bedded, fertilized.

[z] When fungicide × culture interaction is not significant ($P = 0.05$), means for main effects are indicated; for each response variable, means followed by the same letter (a,b) in a row or in the column at the extreme right are not significantly different. When fungicide × culture interaction is significant, main effect means are not shown and letters indicate differences within rows but not columns.

galls occurred mainly in the second, rather than the first year, and the effect of fungicide was highly significant in both years. The fungicide × culture interaction was significant. Percentage of trees with galls in second-year branch tissue was zero in C plots, with and without fungicide. In sprayed treatments, the increases associated with culture levels were not significant; in unsprayed treatments, there was a significant and striking increase with weeding, but no significant further increase with bedding or fertilizer.

The percentage of trees with no infection of any kind in either year also showed a significant interaction, being much reduced by weeding in protected plots but not further reduced by bedding or fertilizer and being unaffected by culture in protected plots. Without fungicide, 71% of the trees were uninfected in C, compared with 46% in W, WB, and WBF plots; with fungicide, 92–96% of the trees were free of rust.

Tree survival in the first year averaged 99%; no significant differences were associated with fungicide, culture, or interaction. Second-year survival was 91% in C and averaged 98% in all other culture levels, increasing only with weeding; interaction and effect of fungicide were not significant.

Mean first-year height of trees was greatest in WBF (33.5 cm) and averaged 26.3 cm in all other culture levels; no significant differences were associated with weeding, bedding, fungicide, or fungicide × culture interaction. Differences in seedling characteristics other than height were readily apparent but not measured; needle length, density of foliage, and size and number of branches increased markedly as intensity of culture increased.

Mean second-year growth was 32.0 cm in C, averaged 60.2 cm in W and WB, and was 94.2 cm in WBF. The positive growth response to fertilizer was not accompanied by an increase in rust incidence.

Mean second-year height was 57.9 cm in C, averaged 86.8 cm in W and WB, and was 128 cm in WBF treatments. The fertilizer × culture interaction and the effect of fungicide were not significant.

DISCUSSION

The fact that stem galls of stem origin were more abundant in first- than in second-year tissue, whereas branch galls were more numerous in second- than in first-year tissue can be explained by the common observation that branches are more numerous in the second year. The small percentage of trees with infection in second-year stem tissue must be viewed with caution because of potential latent gall development. In trees as small as these, the gall count for tissue of any year usually is higher and more accurate when made the year following tissue formation.

Triadimefon effectively controlled the incidence of fusiform rust during the first 2 yr. This control should permit an accurate evaluation of the effects of intensive culture on tree growth. With no control, after a few years most of the stem-galled trees will be deformed and stunted.

Realistic cost-benefit analysis cannot be attempted in plots as small as those in this study, and triadimefon cannot be recommended for general use in operational reforestation. However, these results indicate the usefulness of triadimefon for protecting small, intensively cultured, high-value plantings such as research plots.

Although the apparent failure of culture to influence stem gall development is surprising (4,5), it is not an unheard-of situation (3); however, weeding did influence incidence of branch galls. The fact that fertilization did not influence rust in this study was striking. A more elaborate study featuring several levels of fertilizer might define the relation more clearly.

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